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Okumura

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(54) **GLOW PLUG TERMINAL AND GLOW PLUG**

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F23Q 7/22 (2006.01)
H01R 43/00 (2006.01)
F23Q 7/00 (2006.01)

(52) **U.S. Cl.**

CPC ***H01R 43/00*** (2013.01); ***F23Q 7/001*** (2013.01); ***F23Q 7/22*** (2013.01); ***H01R 13/04*** (2013.01); *Y10T 29/49204* (2015.01)

(58) **Field of Classification Search**

CPC F23Q 7/001; F23Q 7/22
See application file for complete search history.

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(57) **ABSTRACT**

A glow plug having a main body bracket, a heater, a center shaft, an insulator, an O-ring that is provided between the front end surface of the insulator and the main body bracket, and a pin terminal that is fitted to the rear end portion of the center shaft and used for supplying electricity from the outside. The pin terminal includes a small-diameter portion, a flange, and a large-diameter portion where an engagement portion and a fitting recess are formed. The large-diameter portion includes a crimp formation region, which is formed so as to have the even outer diameter and be capable of being crimped, in a range from the front end thereof to the front end of the engagement portion. A part of the crimping target portion forms a crimping portion that fixes the rear end portion of the center shaft by crimping.

12 Claims, 11 Drawing Sheets

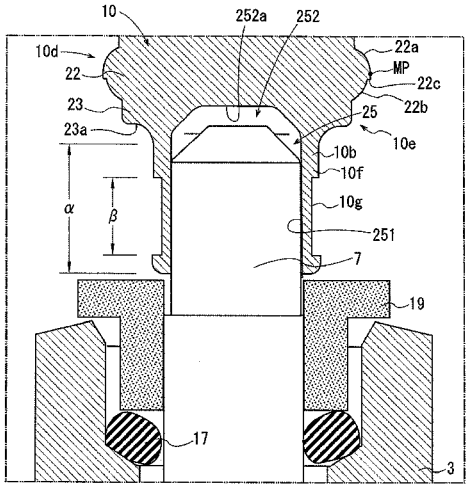

FIG. 1

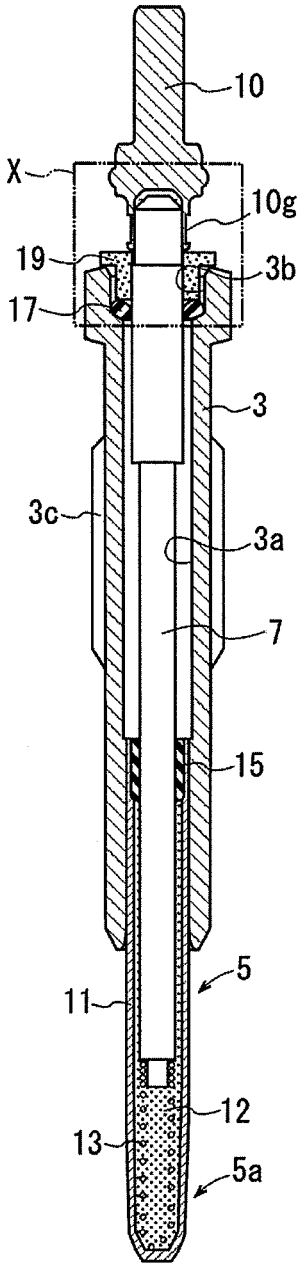

FIG. 2A

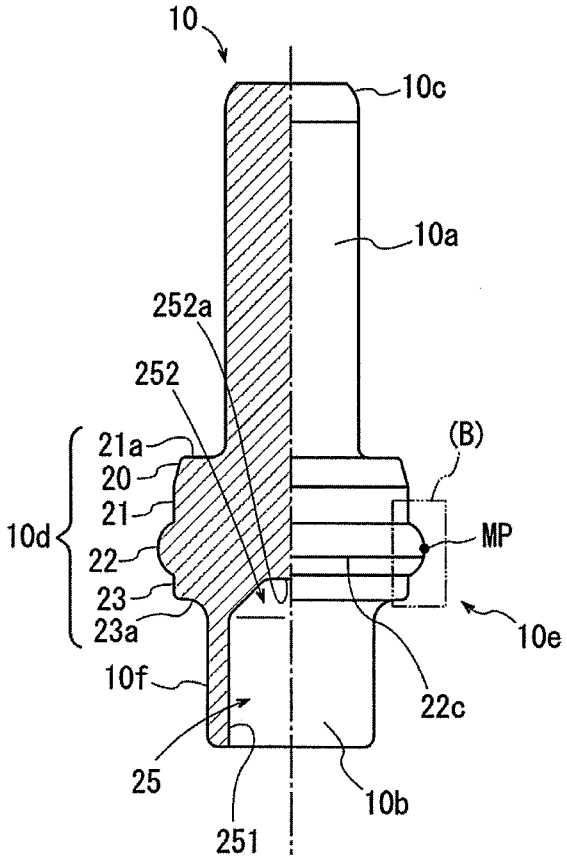
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FIG. 2B

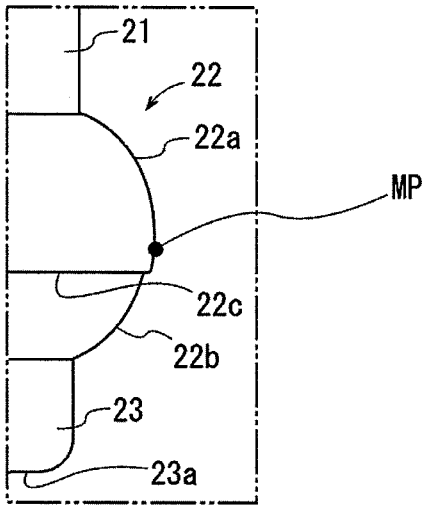
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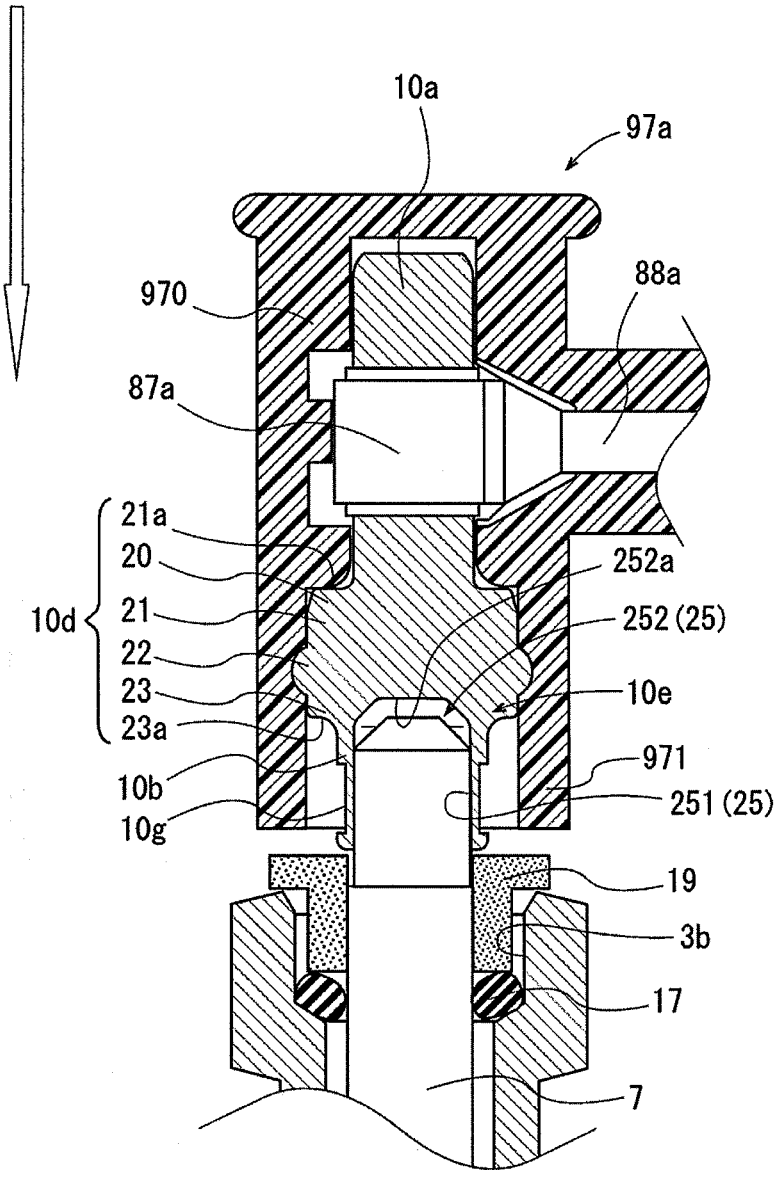
FIG. 3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10g
251 (25)
19
3b
17
7

FIG. 4E

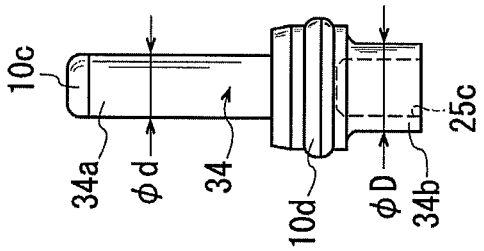

FIG. 4D

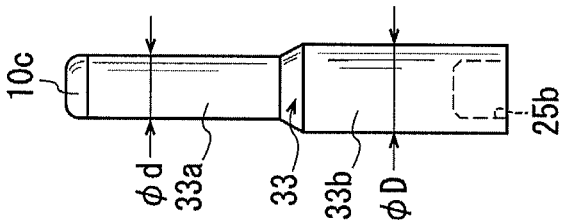

FIG. 4C

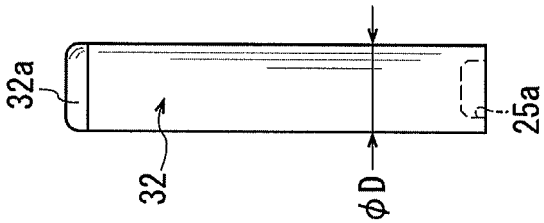

FIG. 4B

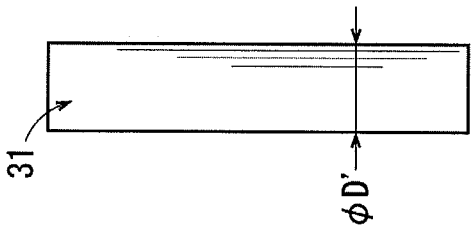

FIG. 4A

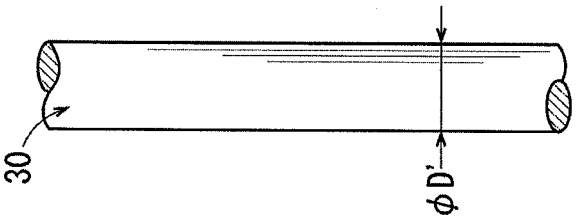

FIG. 5

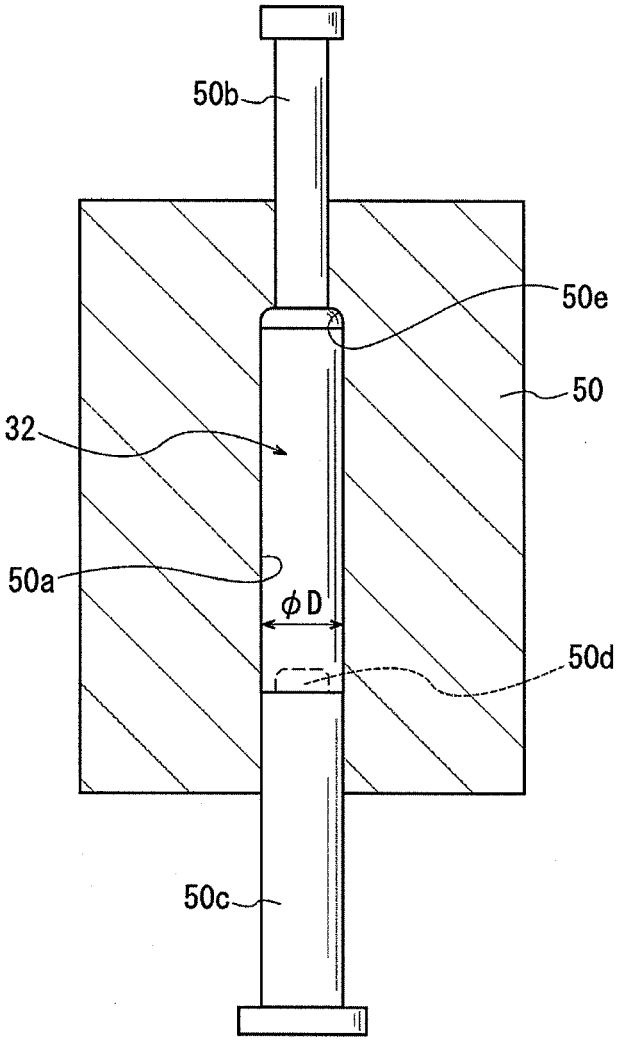

FIG. 6

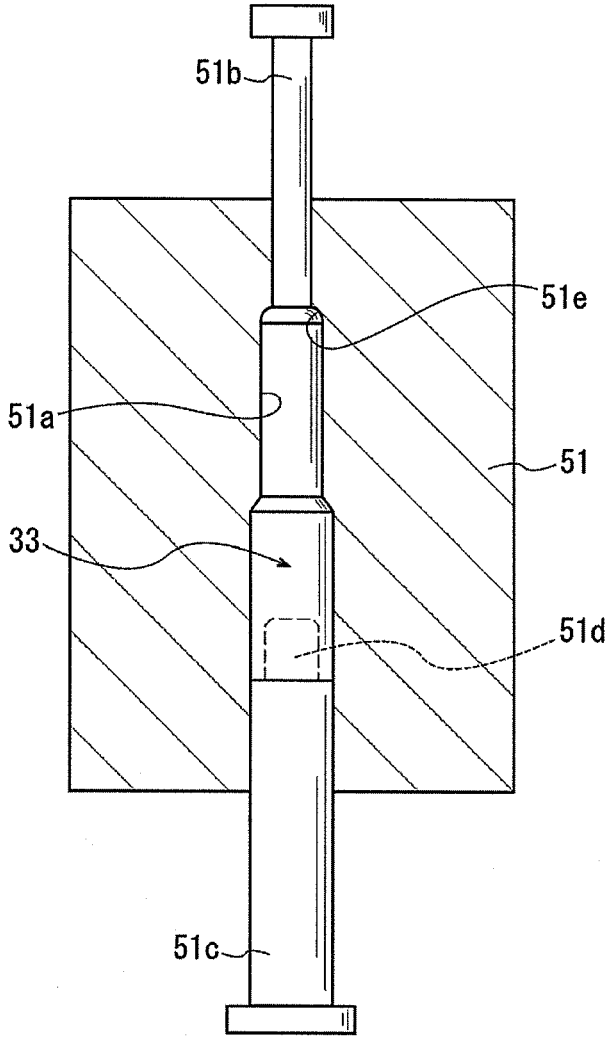

FIG. 7

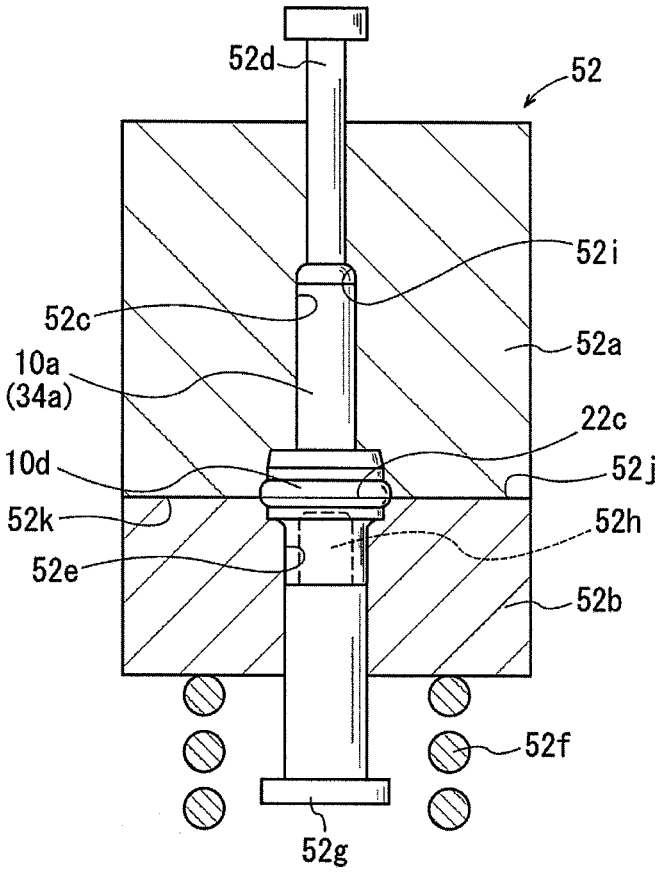

FIG. 8

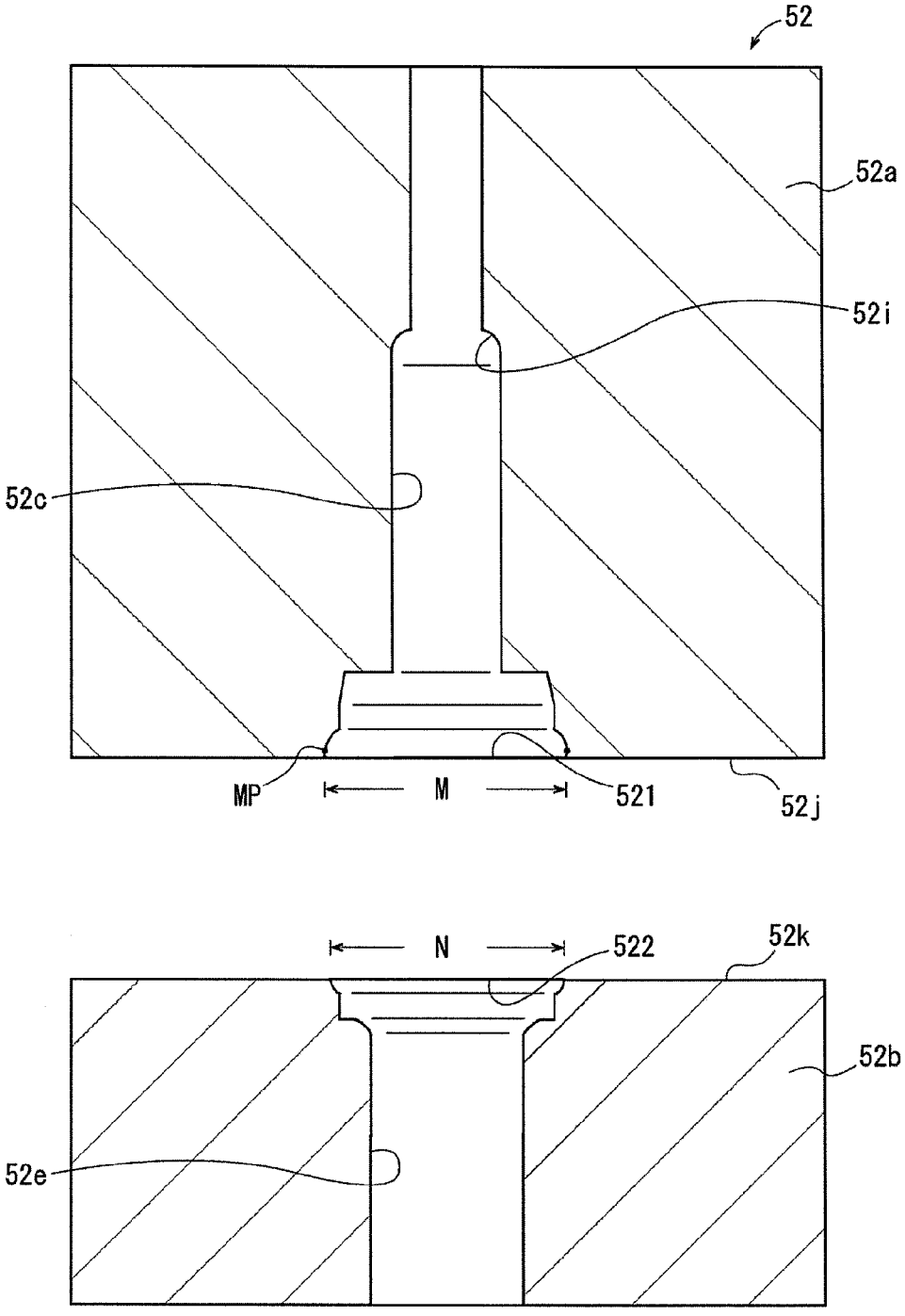

FIG. 9

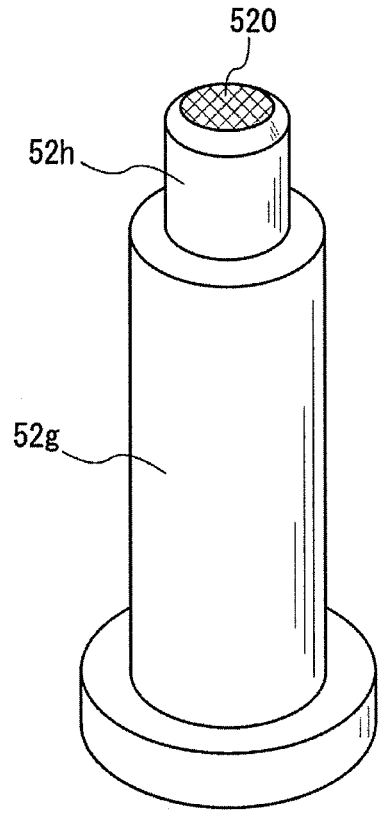

FIG. 10

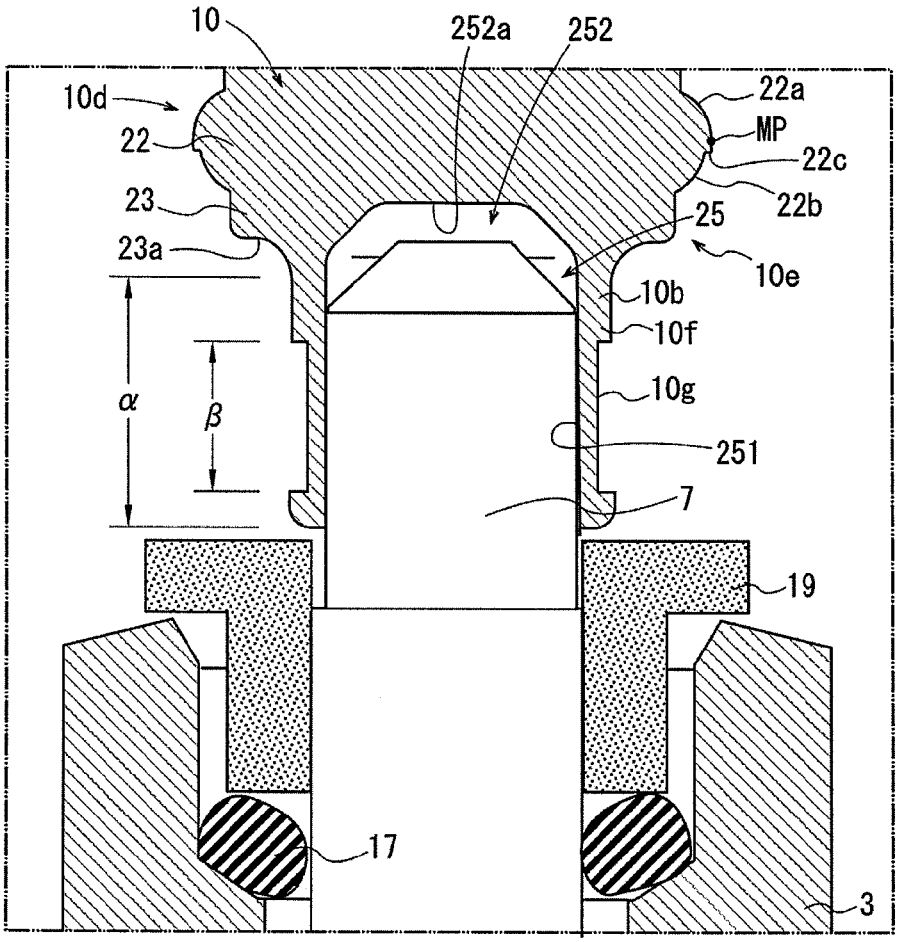
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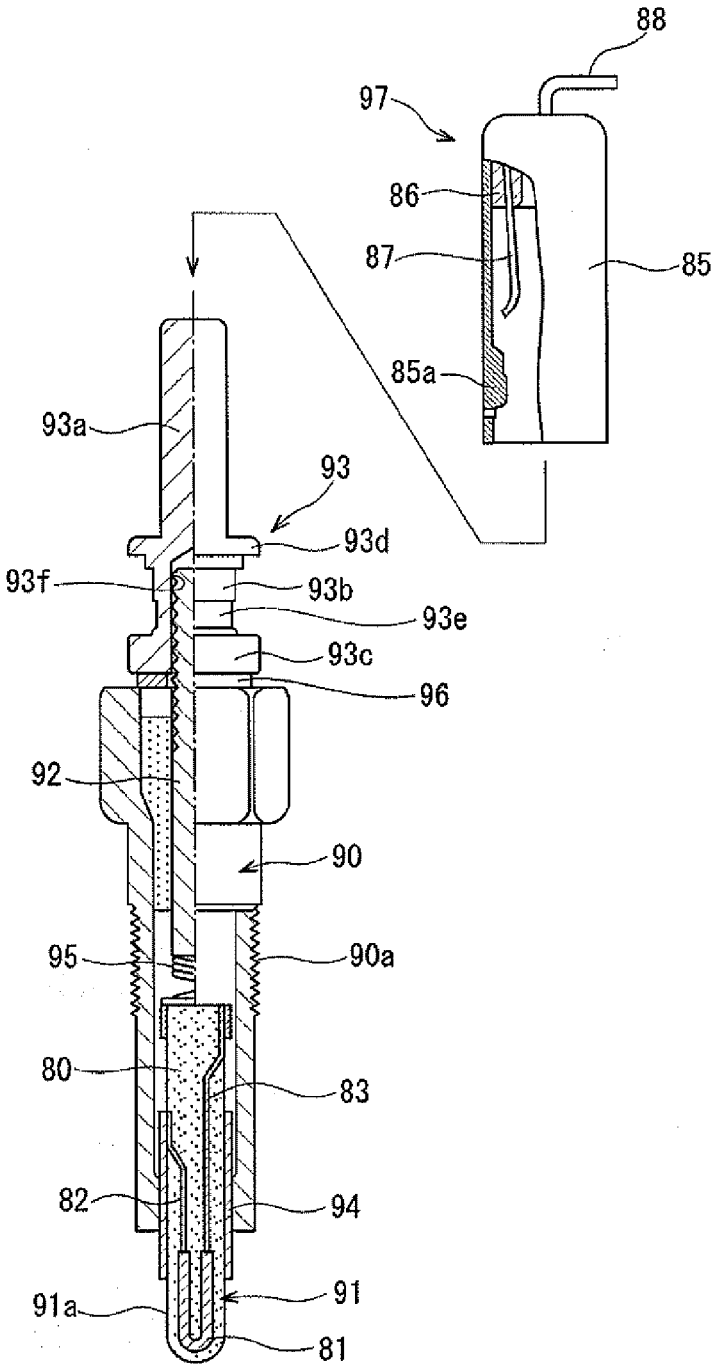
FIG. 11



PRIOR ART

GLOW PLUG TERMINAL AND GLOW PLUG

FIELD OF THE INVENTION

The present invention relates to a pin terminal for a glow plug and a glow plug.

BACKGROUND OF THE INVENTION

JP-A-2002-260827 discloses a conventionally known glow plug. As shown in FIG. **11**, the glow plug includes a cylindrical housing **90**, a heater **91** that is fixed in the housing **90** and includes a heat generating portion **91***a* protruding from the front end of the housing **90**, a rod-like center shaft **92** which is disposed in the housing **90** and includes the rear end portion protruding from the rear end of the housing **90**, and a pin terminal **93** that is fitted to the rear end portion of the center shaft **92** and is used to supply electricity to the heat generating portion **91***a* from the outside through the center shaft **92**.

The heater **91** is a ceramic heater which is fitted into an outer cylinder **94** fitted to the front end of the housing **90** and made of a conductive metal and includes the heat generating portion **91***a* protruding from the front end of the outer cylinder **94** and the housing **90**.

The ceramic heater **91** includes a rod-like insulating body **80** that contains Si_3N_4 as a main component, a U-shaped heat generating body **81** that is embedded in the front end portion of the insulating body **80** and contains WC as a main component, a first lead wire **82** having one end connected to one end of the heat generating body **81** and the other end exposed to a part of the outer peripheral surface of the insulating body **80**, and a second lead wire **83** having one end connected to the other end of the heat generating body **81** and the other end exposed to the other part of the outer peripheral surface of the insulating body **80**. The other end of the first lead wire **82** itself is connected to the outer cylinder **94**, the other end of the second lead wire **83** itself is connected to a current-carrying coil **95**, and the current-carrying coil **95** is connected to the center shaft **92**. The front end portion of the insulating body **80**, in which the heat generating body **81** is embedded, is the heat generating portion **91***a* of the ceramic heater **91**.

The pin terminal **93** includes a small-diameter portion **93***a* that is formed at the rear end portion thereof and a large-diameter portion **93***b* that is formed at the front end portion thereof. The rear end surface of the small-diameter portion **93***a* has the shape of a curved surface. A first flange **93***c*, which comes into contact with an insulator **96** provided at the rear end portion of the housing **90** and made of an insulating material, is formed at the front end portion of the large-diameter portion **93***b*. Further, a second flange **93***d* is formed at the rear end portion of the large-diameter portion **93***b*, and an engagement portion **93***e* to which an engagement protrusion **85***a* of a cap **97** making current flow from the outside is locked is formed between the first and second flanges **93***c* and **93***d*.

When male threads **90***a* of the housing **90** are engaged with a cylinder head of a diesel engine, the heat generating portion **91***a* of the ceramic heater **91** is positioned in the combustion chamber of the diesel engine. Further, the housing **90** is grounded to the cylinder head, and the cap **97** connected to a battery is fitted to the pin terminal **93**. The cap **97** includes a cup-shaped cap main body **85** and a conductive member **87**. The conductive member **87** is fixed by a fixing member **86**, which is provided inner side of the cap main body **85**, so as to extend from the inner side toward an open portion. An engagement protrusion **85***a*, which protrudes inward, is formed on the inner portion of the cap main body **85** close to the open portion. The conductive member **87** is connected to a lead wire **88** that is connected to a battery.

When the cap **97** is fitted to the pin terminal **93**, the engagement protrusion **85***a* of the cap main body **85** gets over the second flange **93***d* and is engaged with the engagement portion **93***e*. In this state, the conductive member **87** comes into contact with the surface of the small-diameter portion **93***a*.

Accordingly, a voltage is applied between the housing **90**, the outer cylinder **94** and the first lead wire **82**, the pin terminal **93**, the center shaft **92**, and the current-carrying coil **95** and the second lead wire **83**, so that the heat generating portion **91***a* of the ceramic heater **91** generates heat by the heat generating body **81**. In so doing, the diesel engine starts.

However, the pin terminal in the related art includes the first flange formed at the front end portion of the large-diameter portion and the second flange formed at the rear end of the large-diameter portion. Accordingly, in the pin terminal, the crimp formation region, which is formed so as to have the even outer diameter and be capable of being crimped, is limited between the first and second flanges and is short. For this reason, since it is difficult to solidly join the center shaft to the pin terminal by the short crimp formation region, the joint strength between the center shaft and the pin terminal should be ensured by employing a slightly long center shaft. For this reason, in the pin terminal, the reduction in the amount of material has been insufficient and the reduction in weight has been insufficient. Further, since the glow plug also employs the pin terminal and employs a slightly long center shaft, the reduction in the amount of material is insufficient and the reduction in weight is insufficient.

SUMMARY OF THE INVENTION

The present invention has been made in consideration of the above-mentioned circumstances. An advantage of the invention is a pin terminal that can be joined to a center shaft with high joint strength and that achieves a reduction in the amount of material and weight of a glow plug. Further, another advantage of the present invention is a glow plug that provides excellent durability through the joining between a center shaft and a pin terminal with high joint strength and can achieve a reduction in the amount of material and weight.

A pin terminal for a glow plug of the present invention comprises:

a small-diameter portion which has a shaft shape extending in an axial direction and is to be connected to a conductive member for supplying electric power from an outside;

a flange that is formed integrally with a front end of the small-diameter portion and is formed so as to have an outer diameter larger than an outer diameter of the small-diameter portion;

a cylindrical large-diameter portion that is formed integrally with a front end of the flange so as to be shorter than the small-diameter portion in the axial direction, is formed so as to have an outer diameter larger than the outer diameter of the small-diameter portion and smaller than the outer diameter of the flange, and includes a fitting recess formed therein in a radial direction so as to be recessed toward a rear end of the large-diameter portion from a front end of the large-diameter portion in the axial direction; and

an engagement portion which is positioned between a maximum diameter position of the flange and the large-diameter portion and has an outer diameter gradually reduced toward the large-diameter portion,

wherein the large-diameter portion includes a crimp formation region which is formed in a range from a front end of

the large-diameter portion to a front end of the engagement portion so as to have the even outer diameter and be capable of being crimped. (claim **1**)

The first flange **93***c*, which has been formed at the pin terminal **93** in the related art (see FIG. **11**), is not formed at the pin terminal for a glow plug of the invention. Accordingly, in the pin terminal, the overall length thereof is maintained, that is, the compatibility with the cap fitted to the pin terminal is maintained and the length of the crimp formation region, which is formed so as to have the even diameter and can be crimped, is large. For this reason, the center shaft and the pin terminal are easily and solidly joined to each other at the long crimp formation region, and a slightly short center shaft can be employed. Accordingly, a reduction in the amount of material and weight can also be achieved in the pin terminal. Further, since the glow plug also employs the pin terminal and a slightly short center shaft, the glow plug can achieve a reduction in the amount of material and weight.

Meanwhile, as for the operation of the first flange **93***c* of the pin terminal **93** in the related art (see FIG. **11**), at first, it was considered that the first flange **93***c* can sufficiently press the insulator **96** by increasing the contact area between the first flange **93***c* and the rear end of the insulator **96**. Further, it was considered that an O-ring (not shown) provided between the front end surface of the insulator **96** and the housing **90** is elastically deformed into a uniform shape and can improve the insulation property between the center shaft **92** and the housing **90** when the first flange **93***c* sufficiently presses the insulator **96**. However, according to a study conducted by the inventor, as for the pin terminal **93**, it was found that an insulation effect of the O-ring also can be provided since the insulator **96** can be sufficiently pressed even though the contact area between the first flange and the rear end of the insulator **96** is not increased by the first flange **93***c* as in the related art. That is, difference is not generated between the insulation performance of the glow plug including the pin terminal of the invention and the insulation performance of the glow plug in the related art including the pin terminal **93** on which the first flange **93***c* has been formed.

Accordingly, the pin terminal for a glow plug of the invention can be joined to the center shaft with high joint strength and also can achieve the reduction in the amount of material and weight of the glow plug. Since the glow plug includes the pin terminal, the glow plug provides excellent durability at a low price.

It is possible to manufacture the pin terminal for a glow plug of the invention by the plastic working or cutting of a workpiece made of conductive metal. Further, the small-diameter portion, the flange, the large-diameter portion, and the engagement portion of the pin terminal may be formed by plastic working and the fitting recess may be formed by cutting. If the pin terminal is manufactured by only the plastic working of the workpiece made of conductive metal, swarf of the workpiece is not generated during working and it is possible to achieve a reduction in manufacturing cost by saving resources. Accordingly, it is preferable that the pin terminal be manufactured by only the plastic working of the workpiece.

The fact that the crimp formation region is formed so as to have the even outer diameter does not mean that the outer diameter is exactly constant, and also includes a case where the outer diameter is not constant within a certain range, that is, the outer diameter is substantially constant as long as the crimp formation region can be crimped. Since crimping is working that is performed on a cylindrical portion having a constant outer diameter, it is not possible to perform crimping if there is a diameter difference corresponding to the first flange **93***c* in the related art. If a diameter difference is 0.2 mm or less, it may be considered that the outer diameter is constant in the invention.

It is preferable that a diameter of a front end surface of the large-diameter portion is smaller than that of a rear end surface of an insulating member which is a component of the glow plug. (Claim **2**) In this case, it is possible to very reliably prevent current from leaking to the housing or the like from the pin terminal.

It is preferable that the fitting recess includes an inner peripheral surface that extends from the front end of the large-diameter portion toward the rear end of the large-diameter portion, and an upper bottom surface that continues to a rear end of the inner peripheral surface and is positioned inside the engagement portion or the flange in a radial direction of the engagement portion or the flange. (Claim **3**) In this case, it is possible to position the rear end portion of the center shaft, which is fitted to the fitting recess, at the rear end side of the crimp formation region. For this reason, since crimping is performed at the front end side with respect to the rear end portion of the center shaft in the glow plug including the pin terminal, it is possible to more effectively prevent a load from being concentrated on the rear end portion of the center shaft. Accordingly, the durability of the center shaft itself is improved and the durability of the glow plug itself is also improved. Meanwhile, the upper bottom surface means a surface forming the upper bottom of the fitting recess and a region corresponding to a certain range that includes this surface.

According to confirmation by the inventor, when a flange is formed through plastic deformation of the workpiece, distortion or the like easily occurs on the upper bottom surface of the fitting recess formed at the workpiece by the influence of the plastic deformation. Accordingly, wrinkles and the like, which are caused by distortion, are easily formed on the upper bottom surface. Meanwhile, plating is performed on the pin terminal for a glow plug in terms of the protection of the surface of the pin terminal and the like. For this reason, if distortion occurs on the upper bottom surface, cleaning liquid and the like used in the plating remains on the wrinkles and the like of the upper bottom surface, so that the quality of the plating of the fitting recess easily deteriorates. Further, rust and the like are easily generated on the upper bottom surface by the influence of the remaining cleaning liquid and the like. For these reasons, the quality of the pin terminal easily deteriorates.

It is preferable that the upper bottom surface has a tapered shape where a diameter of the upper bottom surface is reduced toward a rear end thereof. (Claim **4**) Since the upper bottom surface has a tapered shape where the diameter of the upper bottom surface is reduced toward the rear end as described above, the thickness of the periphery of the upper bottom surface of the workpiece is increased. Accordingly, it is difficult for the upper bottom surface to be deformed even by plastic deformation when the flange is formed, and it is difficult for distortion or the like to occur on the upper bottom surface. For this reason, it is difficult for cleaning liquid or the like to remain on the upper bottom surface, so that plating is preferably performed on the fitting recess. Further, it is also difficult for rust or the like to occur on the upper bottom surface. For these reasons, the pin terminal has high quality.

It is preferable that the upper bottom surface is positioned at a side of the front end of the flange with respect to the maximum diameter position of the flange. (Claim **5**) The magnitude of the plastic deformation of the workpiece, when the flange is formed through plastic deformation, reaches a maximum at the maximum diameter position of the flange.

For this reason, if the upper bottom surface of the fitting recess is positioned at a side of the front end with respect to the maximum diameter position of the flange, it is possible to further reduce the influence of the plastic deformation on the upper bottom surface. Accordingly, it is more difficult for the deformation of the upper bottom surface caused by plastic deformation to occur, so that the pin terminal has higher quality.

The flange may include a first cylindrical surface that is positioned close to the small-diameter portion and has a diameter larger than the diameter of the small-diameter portion, a convex curved surface which is connected to the first cylindrical surface and of which a cross-section in the axial direction forms an arc and a cross-section in a direction perpendicular to the axial direction has a circular shape, and a second cylindrical surface that is connected to the convex curved surface and has the same diameter as the diameter of the first cylindrical surface. It is preferable that a step is formed on the convex curved surface at a side of the second cylindrical surface with respect to the maximum diameter position. (Claim **6**)

In this case, the cap is easily fitted to the pin terminal due to the first cylindrical surface and the convex curved surface. Further, it is difficult for the cap to be taken out from the pin terminal due to the second cylindrical surface. In this case, it is possible to preferably lock the cap to the engagement portion by using the step. For this reason, for example, even though the cap is deviated from the engagement portion due to vibration and the like and is moved in the direction where the cap is taken out from the pin terminal, the cap is caught by the step. Accordingly, the cap is preferably prevented from being moved toward the rear end from the step. Furthermore, the step itself may function as an engagement portion. Meanwhile, the step may be included in the engagement portion, and the step itself may be used as a engagement portion. In addition, the step may be simultaneously formed when the flange is formed through plastic working, and may be formed by cutting a formed flange.

It is preferable that the flange includes a cylindrical first cylindrical surface that is positioned close to the small-diameter portion and has a diameter larger than the diameter of the small-diameter portion, a convex curved surface which is connected to the first cylindrical surface and of which a cross-section in the axial direction forms an arc and a cross-section in a direction perpendicular to a shaft has a circular shape, and a cylindrical second cylindrical surface that is connected to the convex curved surface and has the same diameter as the diameter of the first cylindrical surface. (Claim **7**) In this case, the cap is more easily fitted to the pin terminal due to the first cylindrical surface and the tapered surface. Further, it is difficult for the cap to be taken out from the pin terminal due to the second disc surface.

A glow plug of the present invention comprises:

a cylindrical housing;

a heater that is fixed in the housing and includes a heat generating portion protruding from a front end of the housing;

a rod-like center shaft which is disposed in the housing and includes a rear end portion protruding from a rear end of the housing;

an insulating member which is provided at the rear end of the housing and into which the center shaft is inserted; and

a pin terminal that is fitted to the rear end portion of the center shaft and used to supply an electricity to the heat generating portion from an outside through the center shaft,

wherein the pin terminal includes:

a small-diameter portion which has the shaft shape extending in an axial direction and is to be connected to a conductive member for supplying electric power from the outside;

a flange that is formed integrally with a front end of the small-diameter portion and is formed so as to have an outer diameter larger than an outer diameter of the small-diameter portion;

a cylindrical large-diameter portion that is formed integrally with a front end of the flange so as to be shorter than the small-diameter portion in the axial direction, is formed so as to have an outer diameter larger than the outer diameter of the small-diameter portion and smaller than the outer diameter of the flange, and includes a fitting recess formed therein in a radial direction so as to be recessed toward a rear end of the large-diameter portion from a front end of the large-diameter portion in the axial direction; and

an engagement portion which is positioned between a maximum diameter position of the flange and the large-diameter portion and has an outer diameter gradually reduced toward the large-diameter portion,

wherein the large-diameter portion includes a crimp formation region, which is formed in a range from a front end of the large-diameter portion to a front end of the engagement portion so as to have the even outer diameter and be capable of being crimped, and

wherein a part of the crimp formation region forms a crimping portion that fixes the rear end portion of the center shaft by crimping. (Claim **8**)

The glow plug of the invention includes the pin terminal of the invention. For this reason, the glow plug provides excellent durability through the joining between the center shaft and the pin terminal with high joint strength and can achieve a reduction in the amount of material and weight. Accordingly, the glow plug provides excellent durability at a low price.

It is preferable that the crimping portion has a length that exceeds a half of an overall length of the crimp formation region in the axial direction. (Claim **9**) In this case, the joint strength between the center shaft and the pin terminal is high as compared to a common product where the length of a crimping portion is equal to or smaller than the half of the overall length of a crimp formation region in the axial direction. Accordingly, the glow plug reliably provides excellent durability.

It is preferable that the crimping portion is positioned at a side of a front end of the crimp formation region with respect to a middle of the crimp formation region in the axial direction. (Claim **10**) In this case, in the glow plug, crimping is performed on the pin terminal at the position that is close to the front end of the large-diameter portion. For this reason, in the glow plug, it is possible to reduce a load applied to the rear end portion of the center shaft. Accordingly, the durability of the glow plug is further improved.

The fitting recess may include an inner peripheral surface that extends from a front end of the large-diameter portion toward a rear end of the large-diameter portion, and an upper bottom surface that continues to a rear end of the inner peripheral surface and is positioned inside the engagement portion or the flange in the radial direction of the engagement portion or the flange. Further, the upper bottom surface may have a tapered shape where a diameter of the upper bottom surface is reduced toward a rear end. Furthermore, the center shaft may have a tapered rear end portion having a diameter reduced

toward a rear end. Moreover, it is preferable that the rear end portion of the center shaft be positioned inside the upper bottom surface (claim **11**).

In this case, since the rear end portion of the center shaft has the above-mentioned tapered shape, the rear end of the center shaft is easily inserted into the fitting recess. Further, the rear end of the center shaft inserted into the fitting recess reaches the upper bottom surface along the inner peripheral surface. In this case, since the upper bottom surface has a tapered shape where a diameter of the upper bottom surface is reduced toward the rear end, it is difficult for the upper bottom surface to be deformed even by plastic deformation as described above. Accordingly, it is difficult for distortion or the like to occur on the upper bottom surface. For this reason, since it is difficult for the fitting recess to be deformed, it is possible to preferably join the center shaft to the pin terminal with high joint strength so that the rear end portion of the center shaft is positioned inside the upper bottom surface. Furthermore, since it is difficult for distortion or the like to occur on the upper bottom surface, plating is preferably performed on the fitting recess and it is also difficult for rust or the like to occur on the upper bottom surface. For these reasons, the durability of the glow plug is further improved.

Here, the upper bottom surface means a surface forming the upper bottom of the fitting recess and a region corresponding to a certain range that includes this surface. For this reason, a fact that the rear end portion of the center shaft is positioned inside the upper bottom surface means a state where the rear end portion of the center shaft comes into contact with a surface forming the upper bottom or the rear end portion of the center shaft approaches the surface to the degree equivalent to this (see FIG. **10**).

Further, it is preferable that the upper bottom surface be positioned at a side of the front end with respect to the maximum diameter position of the flange (claim **12**). It is difficult for the deformation of the upper bottom surface, which is caused by plastic deformation, to occur, so that it is possible to more preferably join the center shaft to the pin terminal with high joint strength. Furthermore, since the upper bottom surface is positioned at the side of the front end with respect to the maximum diameter position of the flange as described above, the depth of the fitting recess is relatively reduced. Accordingly, it is possible to make the rear end of the center shaft short. For this reason, the whole center shaft can be formed to be short, so that it is possible to reduce the manufacturing cost of the glow plug. Meanwhile, even when the depth of the fitting recess is reduced and the rear end of the center shaft becomes short as described above, the joint strength between the center shaft and the pin terminal is maintained high since the crimping portion has a sufficient length as described above.

In the pin terminal for a glow plug of the invention and a glow plug including the pin terminal, the center shaft and the pin terminal can be joined to each other with high joint strength and a reduction in the amount of material and weight of a glow plug can be achieved. For this reason, the glow plug including the pin terminal provides excellent durability at a low price.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional view of a glow plug of an embodiment.

FIG. **2** shows a partial cross-sectional view and a partial enlarged view of a pin terminal of a glow plug of the embodiment that is not yet assembled. FIG. **2**A is a partial cross-sectional view showing the entire pin terminal, and FIG. **2**B is a partial enlarged view showing a convex curved surface.

FIG. **3** is an enlarged cross-sectional view showing a state where a cap and the pin terminal of the glow plug of the embodiment are fitted to each other.

FIGS. **4**A to **4**E show side views of a workpiece at the end of respective steps of a manufacturing method of the embodiment.

FIG. **5** is a cross-sectional view illustrating a second step of the manufacturing method of the embodiment.

FIG. **6** is a cross-sectional view illustrating a third step of the manufacturing method of the embodiment.

FIG. **7** is a cross-sectional view illustrating a fourth step of the manufacturing method of the embodiment.

FIG. **8** is a cross-sectional view showing first and second dies used in the manufacturing method of the embodiment.

FIG. **9** is a perspective view showing a punch used in the manufacturing method of the embodiment.

FIG. **10** is a partially enlarged cross-sectional view of the glow plug of the embodiment.

FIG. **11** is a partial cross-sectional view of a glow plug and the like in the related art.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

An embodiment of the invention will be described below with reference to the drawings.

As shown in FIG. **1**, a glow plug of an embodiment includes a main body bracket **3** as a cylindrical housing, a heater **5** that is fixed in the main body bracket **3** and includes a heat generating portion **5***a* protruding from a front end of the main body bracket **3**, a rod-like center shaft **7** which is disposed in the main body bracket **3** and includes a rear end portion protruding from a rear end of the main body bracket **3**, and a pin terminal **10** that is fitted to the rear end portion of the center shaft **7** and is used to apply an electricity to the heat generating portion **5***a* from the outside through the center shaft **7**.

The heater **5** includes a heat generating tube **11** having a front end being closed. The heat generating tube **11** has the shape of a cylinder extending in the axial direction, and is fixed in the main body bracket **3** so that current can flow while a front end portion of the heat generating tube **11** protrudes from the front end portion of the main body bracket **3**. A front end of the center shaft **7** is positioned in the heat generating tube **11**, and a rear end of the center shaft **7** protrudes from the rear end of the main body bracket **3**. Insulating powder **12** containing MgO as a main component and a heat generating coil **13** are housed in the heat generating tube **11**. A front end portion of the heat generating coil **13** is joined to the front end portion of the heat generating tube **11**, and a rear end portion of the heat generating coil **13** is joined to a front end portion of the center shaft **7**. The heat generating tube **11**, the insulating powder **12**, and the heat generating coil **13** form the heater **5**. Further, the front end portion of the heat generating tube **11** in which the heat generating coil **13** is housed together with the insulating powder **12** is the heat generating portion **5***a* of the heater **5**.

An insulating body **15**, which is formed of rubber packing, is fixed to the middle portion of the outer peripheral surface of the center shaft **7** and an open end of the heat generating tube **11** is crimped around the insulating body **15**, so that the heat generating tube **11** is fixed to the center shaft **7** so as to be insulated from the center shaft **7**.

Further, a large-diameter hole **3***b* of a shaft hole **3***a*, which has the largest diameter, is formed at the rear end portion of

the main body bracket **3**, and an O-ring **17** and an annular insulator **19** made of an insulating material are placed at a stepped portion that faces the rear end and is formed between the shaft hole **3***a* and the large-diameter hole **3***b*. The center shaft **7** is inserted into the respective inner peripheries of the O-ring **17** and the insulator **19**. The O-ring **17** and the insulator **19** correspond to an insulating member. Meanwhile, the insulating member may be formed by integrating the O-ring **17** with the insulator **19**. Further, the insulating member may be formed by the combination of three or more components, and the insulating member may be formed of a single component.

As shown in FIG. **2**A, the pin terminal **10** includes a small-diameter portion **10***a* close to a rear end and a large-diameter portion **10***b* close to a front end. The small-diameter portion **10***a* has the shaft shape extending in the axial direction. A curved surface **10***c* is formed on the outer periphery of a rear end surface of the small-diameter portion **10***a*. Further, a flange **10***d* is formed between the small-diameter portion **10***a* and the large-diameter portion **10***b*. The pin terminal **10** has a shape having a diameter gradually reduced from the flange **10***d* toward the large-diameter portion **10***b*. Furthermore, the small-diameter portion **10***a* and the large-diameter portion **10***b* are separated from each other by the flange **10***d*.

The flange **10***d* includes a first cylindrical surface **21**, a convex curved surface **22**, and a second cylindrical surface **23**. The first cylindrical surface **21** is positioned close to the small-diameter portion **10***a* and has the shape of a cylinder having the diameter which is larger than the diameter of the small-diameter portion **10***a*. The convex curved surface **22** is connected to the first cylindrical surface **21**, the cross-section of the convex curved surface in the axial direction forms an arc, and the cross-section of the convex curved surface in a direction perpendicular to the axial direction has a circular shape. The second cylindrical surface **23** is connected to the convex curved surface **22**, and has the shape of a cylinder having the diameter which is the same as the diameter of the first cylindrical surface **21**.

In addition, the flange **10***d* includes a first disc surface **21***a*, a tapered surface **20**, and a second disc surface **23***a*. The first disc surface **21***a* is connected to the small-diameter portion **10***a*, and extends in the direction perpendicular to the axial direction. The tapered surface **20** is connected to the first cylindrical surface **21** at the front end portion thereof, and is connected to the first disc surface **21***a* at the rear end portion thereof. The tapered surface **20** is formed so that the rear end portion of the tapered surface has a small diameter. The second disc surface **23***a* connects the second cylindrical surface **23** to the large-diameter portion **10***b*, and extends in the direction perpendicular to the axial direction. Meanwhile, a connecting portion between the second disc surface **23***a* and the large-diameter portion **10***b* has an arc shape. Accordingly, the second disc surface **23***a* and the large-diameter portion **10***b* are smoothly connected to each other.

Further, as shown in FIG. **2**B, while a portion slightly at the side of the front end with respect to the maximum diameter position MP of the flange **10***d* be as a boundary, the convex curved surface **22** includes a first arc **22***a* that is formed toward the first cylindrical surface **21** from the portion slightly at the side of the front end with respect to the maximum diameter position MP and a second arc **22***b* that is formed toward the second cylindrical surface **23** from the portion slightly at the side of the front end with respect to the maximum diameter position MP. That is, a portion including the first arc **22***a* is the rear end portion of the convex curved surface **22**, and a portion including the second arc **22***b* is the front end portion of the convex curved surface **22**. Furthermore, a step **22***c* is formed at a boundary between the first arc **22***a* and the second arc **22***b*, that is, on the outer peripheral surface of the portion of the convex curved surface **22** that is slightly at the side of the front end with respect to the maximum diameter position MP. The second cylindrical surface **23** and the step **22***c* correspond to a engagement portion **10***e*. Meanwhile, the shape of the step **22***c* will be described in detail below.

Here, the engagement portion **10***e* may be formed between the maximum diameter position MP of the flange **10***d* and the large-diameter portion **10***b*, and is not limited to the second cylindrical surface **23** and the step **22***c* as described above. For example, the step **22***c*, the second cylindrical surface **23**, and the second disc surface **23***a* may be used as the engagement portion **10***e*. Further, any one of the step **22***c*, the second cylindrical surface **23**, and the second disc surface **23***a* may be used as the engagement portion **10***e*. Furthermore, the combination of the second cylindrical surface **23** and the second disc surface **23***a* may be used as the engagement portion **10***e*.

As shown in FIG. **2**A, the large-diameter portion **10***b* is formed integrally with the front end of the small-diameter portion **10***a* and is formed so as to have an outer diameter larger than the outer diameter of the small-diameter portion **10***a* and smaller than the outer diameter of the flange **10***d*. Further, the diameter of the front end surface of the large-diameter portion **10***b* is smaller than the diameter of the rear end surface of the insulator **19** (see FIG. **10**) to be described below.

Furthermore, in the pin terminal **10** which is not yet assembled, a range of from the front end of the large-diameter portion **10***b* to the front end of the engagement portion **10***e* have substantially the even outer diameter since being formed so as to have a diameter difference of 0.2 mm or less. Moreover, this range is a crimp formation region **10***f*.

In addition, a fitting recess **25** into which the center shaft **7** is fitted is formed at the front end surface of the large-diameter portion **10***b*. The fitting recess **25** includes an inner peripheral surface **251** and an upper bottom surface **252** that are formed in the pin terminal **10**. The inner peripheral surface **251** extends from the front end of the large-diameter portion **10***b* toward the rear end of the large-diameter portion, and the upper bottom surface **252** continues to the rear end of the inner peripheral surface **251** and is positioned inside the flange **10***d* in the radial direction. The upper bottom surface **252** is a surface **252***a* forming the upper bottom of the fitting recess **25** and a region corresponding to a certain range that includes the surface **252***a*. Further, the upper bottom surface **252** has a tapered shape where the diameter of the upper bottom surface is reduced from the front end of the pin terminal **10** toward the rear end. Furthermore, the upper bottom surface **252** is positioned in the pin terminal **10** at the side of the front end with respect to the maximum diameter position MP of the flange **10***d*, more specifically, is positioned in the pin terminal **10** at a position corresponding to the second cylindrical surface **23**.

A cap **97***a*, which is used to apply an electricity to the pin terminal from the outside, is mounted on the pin terminal **10** as shown in FIG. **3**. The cap **97***a* includes a cup-shaped cap main body **970** and a conductive member **87***a* that is fixed to the back side of the cap main body **970**. The cap main body **970** is made of a resin. Further, a portion **971** to be locked is formed on the inside of the open portion of the cap main body **970**. Meanwhile, the conductive member **87***a* is connected to a lead wire **88***a* that is connected to a battery (not shown).

In the manufacture of the glow plug, the pin terminal **10** is manufactured by the following respective steps.

First Step

First, a rod **30**, which has a diameter ϕD' and a circular cross-section and is made of steel as conductive metal, is prepared as shown in FIG. **4**A. A first workpiece **31** having a predetermined length as shown in FIG. **4**B is obtained by cutting the rod **30** in the direction perpendicular to the axial direction.

Second Step

An end surface adjusting die **50**, which has a cavity **50***a* as shown in FIG. **5**, is prepared. The inner diameter of the cavity **50***a* is denoted by ϕD, and is slightly larger than ϕD'. The ϕD is substantially the same as the outer diameter of the large-diameter portion **10***b* of the pin terminal **10** shown in FIG. **2**.

As shown in FIG. **5**, a curved surface **50***e* is formed at the upper end of the cavity **50***a*. Further, a kickout pin **50***b* is provided at the upper end of the cavity **50***a*, and a punch **50***c* is provided at the lower end of the cavity **50***a* so as to be capable of applying pressure in the cavity **50***a*. A protrusion **50***d* having a first height is formed on the upper end surface of the punch **50***c*. Meanwhile, the first height is a height corresponding to a first depth.

Further, the first workpiece **31** is conveyed into the cavity **50***a* of the end surface adjusting die **50**, and pressure is applied to the first workpiece **31** by the punch **50***c*. Accordingly, the rear end surface of the first workpiece **31** comes into pressure contact with the kickout pin **50***b* and the curved surface **50***e*, and the first workpiece **31** is adjusted and subjected to plastic working.

In this way, the first workpiece **31** is formed into a second workpiece **32** that includes a curved surface **32***a* at the rear end surface thereof as shown in FIG. **4**C. For this reason, even though recesses and protrusions are formed on the rear end surface of the first workpiece or the end surface of the first workpiece is inclined when the first workpiece **31** is prepared, the recesses and protrusions do not expand by extruding or the like and the obtained second workpiece **32** is not unexpectedly deformed. Further, a first fitting recess **25***a* having the first depth is formed at the front end surface of the second workpiece **32** by the protrusion **50***d*.

After that, the punch **50***c* is moved down and the second workpiece **32** is taken out from the end surface adjusting die **50** by the kickout pin **50***b*.

Third Step

Then, an extrusion die **51**, which has a cavity **51***a* having the upper portion formed so as to have a small diameter as shown in FIG. **6**, is prepared.

A curved surface **51***e* is formed at the upper end of the cavity **51***a*. Further, a kickout pin **51***b* is provided at the upper end of the cavity **51***a*, and a punch **51***c* is provided at the lower end of the cavity **51***a* so as to be capable of applying pressure in the cavity **51***a*. A protrusion **51***d*, which has a second height larger than the first height, is formed on the upper end surface of the punch **51***c*. Meanwhile, the second height is a height corresponding to a second depth.

Further, the second workpiece **32** is conveyed into the cavity **51***a* of the extrusion die **51** so that the curved surface **32***a* faces upward, and pressure is applied to the second workpiece **32** by the punch **51***c*. Accordingly, the rear end surface of the second workpiece **32** comes into pressure contact with the kickout pin **51***b* and the curved surface **51***e* again, and the second workpiece **32** is adjusted and subjected to plastic working.

In this way, the second workpiece **32** is formed into a third workpiece **33** having the diameter which is reduced at the rear end portion thereof as shown in FIG. **4**D. The rear end portion of the third workpiece **33** forms a small-diameter portion **33***a* having ϕd and the front end portion thereof forms a large-diameter portion **33***b* having ϕD larger than ϕd. The diameter of the curved surface **32***a* is reduced, so that the end surface of the small-diameter portion **33***a* is formed into the curved surface **10***c* corresponding to the product shape. Further, a second fitting recess **25***b*, which has the second depth larger than the first depth, is formed at the front end surface of the third workpiece **33** by the protrusion **51***d*. After that, the punch **51***c* is moved down and the third workpiece **33** is taken out from the extrusion die **51** by the kickout pin **51***b*.

Fourth Step

A flange forming die **52**, which includes a first die **52***a* and a second die **52***b* as shown in FIG. **7**, is prepared in a fourth step. The second die **52***b* is urged toward the first die **52***a* by a pressing spring **52***f*.

A first cavity **52***c*, which matches the small-diameter portion **10***a*, the tapered surface **20**, the first cylindrical surface **21**, and the first arc **22***a* of the convex curved surface **22** of the flange **10***d* shown in FIG. **2**, is formed in the first die **52***a* as shown in FIG. **8**. That is, a portion of the pin terminal, which is close to the rear end of the pin terminal from the first arc **22***a* of the flange **10***d*, can be formed by the first cavity **52***c*. Further, the first cavity **52***c* is formed so that the upper end of the small-diameter portion **33***a* is disposed in the first die **52***a* when the third workpiece **33** shown in FIG. **4**D is disposed. Furthermore, a curved surface **52***i* is formed at the upper end of the first cavity **52***c*.

Meanwhile, a second cavity **52***e*, which matches the second cylindrical surface **23**, the second arc **22***b* of the convex curved surface **22**, and the large-diameter portion **10***b* of the flange **10***d* shown in FIG. **2**, is formed in the second die **52***b*. That is, a portion of the pin terminal, which is close to the front end of the pin terminal from the second arc **22***b* of the flange **10***d*, can be formed by the second cavity **52***e*.

Here, as described above, the first arc **22***a* and the second arc **22***b* of the pin terminal **10** are formed on the rear and front sides of a portion, which is slightly at the side of the front end with respect to the maximum diameter position MP of the flange **10***d*, as a boundary, respectively (see FIG. **2**B). That is, as shown in FIG. **8**, mating surfaces **52***j* and **52***k* of the respective first and second cavities **52***c* and **52***e* of the first and second dies **52***a* and **52***b* are located at the side of the front end with respect to the maximum diameter position MP.

Further, a first round hole **521** matching the first arc **22***a* is formed on the mating surface **52***j* of the first die **52***a*. Likewise, a second round hole **522** matching the second arc **22***b* is formed on the mating surface **52***k* of the second die **52***b*. The maximum diameter N of the second round hole **522** is smaller than the maximum diameter M of the first round hole **521**.

Furthermore, as shown in FIG. **7**, a kickout pin **52***d* is provided at the upper end of the first cavity **52***c*. Meanwhile, a punch **52***g* is provided at the lower end of the second cavity **52***e* so as to be capable of applying pressure in the second cavity **52***e*. As shown in FIG. **9**, a protrusion **52***h*, which has a third height larger than the second height, is formed on the upper end surface of the punch **52***g*. The third height is a height corresponding to a third depth, and more specifically, a height from the front end of the third workpiece **33** to a

position corresponding to the second cylindrical surface **23** of the flange **10***d*. The protrusion **52***h* has a tapered shape where the diameter of the protrusion **52***h* is reduced toward an upper end surface **520** of the protrusion **52***h*. Further, knurling is performed on the upper end surface **520** of the protrusion **52***h*.

As shown in FIG. **7**, the third workpiece **33** is conveyed into the first and second cavities **52***c* and **52***e* of the first and second dies **52***a* and **52***b* so that the small-diameter portion **33***a* is positioned on the upper side, that is, in the first die **52***a*, and pressure is applied to the third workpiece **33** by the punch **52***g*. Accordingly, the rear end surface of the third workpiece **33** comes into pressure contact with the kick-out pin **52***d* and the curved surface **52***i*, and the third workpiece **33** is adjusted and subjected to plastic working. In this way, the third workpiece **33** is formed into a fourth workpiece **34** as shown in FIG. **4**E.

The rear end portion of the fourth workpiece **34** is a small-diameter portion **34***a* that is the same as the small-diameter portion **33***a* of the third workpiece **33**. Further, the flange **10***d* is formed between a large-diameter portion **34***b*, which is the same as the large-diameter portion **33***b* of the third workpiece **33**, and the small-diameter portion **34***a*. In this case, due to a difference between the maximum diameter M of the first round hole **521** of the first cavity **52***c* and the maximum diameter N of the second round hole **522** of the second cavity **52***e*, the step **22***c* is formed on the outer peripheral surface of the flange **10***d* at the portion slightly at the side of the front end with respect to the maximum diameter position MP. The step **22***c* has a shape where the step falls down toward the front end of the convex curved surface **22** (the front end of the fourth workpiece **34**). Meanwhile, the end surface of the small-diameter portion **34***a* remains in the form of the curved surface **10***c*. Further, a third fitting recess **25***c*, which has a third depth larger than the second depth, is formed at the front end surface of the fourth workpiece **34** by the protrusion **52***h*.

After that, the punch **52***g* and the second die **52***b* are moved down and the fourth workpiece **34** is taken out from the flange forming die **52** by the kick-out pin **52***d*. Meanwhile, the small-diameter portion **34***a* formed at the fourth workpiece **34** corresponds to the small-diameter portion **10***a* shown in FIG. **2**. Likewise, the large-diameter portion **34***b* formed at the fourth workpiece **34** corresponds to the large-diameter portion **10***b* shown in FIG. **2**, and the third fitting recess **25***c* corresponds to the fitting recess **25** shown in FIG. **2**.

Outer Diameter Finishing Step

After that, the outer diameter finishing step of performing cutting by a cutter or the like is performed on the outer periphery of the fourth workpiece **34**. Accordingly, it is possible to improve the roundness of the outer periphery of the flange **10***d* of the fourth workpiece **34** by cutting, for example, the outer periphery of the flange **10***d*. The pin terminal **10** shown in FIG. **2** is manufactured through the outer diameter finishing step. Meanwhile, it may be possible to perform the outer diameter finishing step by performing polishing using a grinder or the like instead of the cutting performed by a cutter or the like.

Meanwhile, the main body bracket **3**, the heat generating tube **11**, the insulating body **15**, the heat generating coil **13**, the center shaft **7**, the O-ring **17**, the insulator **19**, and the like are prepared as shown in FIG. **1**. Further, these are assembled with each other and the assembled-body is fitted to the pin terminal **10** by a commonly known method so that necessary portions of these are electrically connected to each other. In this case, while the rear end portion of the center shaft **7** is fitted to the fitting recess **25**, the crimp formation region **10***f* (see FIG. **2**A) of the pin terminal **10** is actually crimped at the rear end portion of the insulator **19**. Accordingly, the center shaft **7** and the pin terminal **10** are jointed to each other as shown in FIGS. **1** and **10**, so that assembly is completed. Further, a crimping portion **10***g* is formed on the outer peripheral surface of the large-diameter portion **10***b*, that is, the crimp formation region **10***f*. As shown in FIG. **10**, the length β of the crimping portion **10***g* is set to a length that exceeds half of the overall length α of the crimp formation region **10***f* in the axial direction. Furthermore, when crimping is performed, a crimping position is adjusted so that the crimping portion **10***g* is positioned at the side of the front end with respect to the middle of the crimp formation region **10***f* in the axial direction, that is, is positioned close to the front end of the large-diameter portion **10***b* of the pin terminal **10**. In this way, a glow plug is completed.

When male threads **3***c* of the main body bracket **3** are engaged with a cylinder head of a diesel engine, the heat generating portion **5***a* of the heater **5** of the glow plug, which is obtained in this way, is positioned in a combustion chamber of the diesel engine. Further, the main body bracket **3** is grounded to the cylinder head, and the cap **97***a* shown in FIG. **3** is fitted to the pin terminal **10**.

When the cap **97***a* is press-fitted to the pin terminal **10** in the direction of an arrow shown in FIG. **3**, the portion **971** to be locked is locked to the engagement portion **10***e*, so that the cap **97***a* is fitted to the pin terminal **10**. In this state, the conductive member **87***a* is connected to the small-diameter portion **10***a*. Accordingly, electric power is supplied to the pin terminal **10**, eventually, to the glow plug through the conductive member **87***a*.

Therefore, a voltage is applied between the main body bracket **3** and the pin terminal **10** and the center shaft **7**, so that the heat generating portion **5***a* of the heater **5** generates heat by the heat generating coil **13**. Accordingly, the diesel engine starts.

A first flange **93***c*, which is formed at a pin terminal **93** (see FIG. **11**) of a glow plug in the related art, is not formed at the front end portion of the pin terminal **10** of the glow plug. For this reason, in the glow plug, as shown in FIGS. **1** and **10**, the front end surface of the pin terminal **10**, that is, the front end surface of the large-diameter portion **10***b*, comes into contact with the rear end surface of the insulator **19**. Accordingly, the insulator **19** is pressed. Further, in this state, the insulator **19** presses the O-ring **17** at the front end thereof. For this reason, the O-ring **17** is elastically deformed in the shaft hole **3***a*, and the O-ring **17** comes into close contact with the center shaft **7**, the insulator **19**, and the wall surface of the shaft hole **3***a*. In this way, an insulation effect, which is caused between the center shaft **7** and the main body bracket **3** by the O-ring **17**, is sufficiently provided in the glow plug.

Further, the first flange **93***c* is not formed as described above. Accordingly, as shown in FIG. **10**, in the pin terminal **10**, the overall length thereof is maintained, that is, the compatibility with the cap **97** fitted to the pin terminal **10** is maintained and the length of the crimp formation region **10***f*, which is formed so as to have the even diameter and can be crimped, (the overall length α of the crimp formation region **10***f*, which corresponds to a straight portion of the large-diameter portion **10***b*, in the axial direction) is large. For this reason, the center shaft **7** and the pin terminal **10** are easily and solidly joined to each other at the long crimp formation region **10***f*, and a slightly short center shaft **7** can be employed in the glow plug. Accordingly, the glow plug including the pin terminal **10** achieves a reduction in the amount of material and weight.

Further, the length β of the crimping portion **10***g*, when crimping has been actually performed, becomes a length that exceeds half of the overall length α of the crimp formation region **10***f* in the axial direction. For this reason, in the glow plug, the joint strength between the center shaft **7** and the pin terminal **10** is high as compared to a common product (see FIG. **11**) where the length of a crimping portion is equal to or smaller than half of the overall length of a crimp formation region in the axial direction. Accordingly, the glow plug reliably provides excellent durability.

Moreover, as shown in FIG. **10**, the crimping portion **10***g* is positioned at the side of the front end with respect to the middle of the crimp formation region **10***f* in the axial direction. For this reason, in the glow plug, crimping is performed on the pin terminal **10** at the position that is close to the front end of the large-diameter portion **10***b*. Accordingly, in the glow plug, it is possible to reduce a load applied to the rear end portion of the center shaft **7**. As a result, the durability of the glow plug is further improved.

Accordingly, the glow plug provides excellent durability through the joining between the center shaft **7** and the pin terminal **10** with high joint strength, and can achieve a reduction in the amount of material and weight.

Particularly, the diameter of the front end surface of the large-diameter portion **10***b* of the pin terminal **10** of the glow plug is smaller than the diameter of the rear end surface of the insulator **19** of the glow plug. For this reason, it is possible to very reliably prevent current from leaking to the main body bracket **3** from the pin terminal **10**.

Further, as shown in FIG. **2**A, the fitting recess **25** of the pin terminal **10** of the glow plug includes the inner peripheral surface **251** that extends from the front end of the large-diameter portion **10***b* toward the rear end of the large-diameter portion and the upper bottom surface **252** that continues to the rear end of the inner peripheral surface **251** and is positioned inside the pin terminal in the radial direction between the engagement portion **10***e* and the flange **10***d*. Accordingly, as shown in FIG. **10**, in the glow plug, it is possible to position the rear end portion of the center shaft **7**, which is fitted to the fitting recess **25**, at the rear of the crimping portion **10***g* formed at the crimp formation region **10***f*. For this reason, since crimping is performed at the side of the front end with respect to the rear end portion of the center shaft **7** in the glow plug, it is possible to more effectively prevent a load from being concentrated on the rear end portion of the center shaft **7**. Accordingly, the durability of the center shaft **7** itself is improved and the durability of the glow plug itself is also improved.

Furthermore, since the upper bottom surface **252** has a tapered shape where the diameter of the upper bottom surface is reduced toward the rear end and the fitting recess **25** has the third depth in the pin terminal **10**, the upper bottom surface **252** is positioned in the pin terminal **10** at the position corresponding to the second cylindrical surface **23**. For this reason, in the fourth step of obtaining the pin terminal **10**, the thickness of the periphery of the upper bottom surface **252** is increased at the third workpiece **33** in which the third fitting recess **25***c* is formed. Accordingly, it is difficult for the upper bottom surface of the third fitting recess **25***c* (which corresponds to the upper bottom surface **252** of the fitting recess **25**) to be deformed even by plastic deformation when the flange **10***d* is formed, and it is difficult for distortion or the like to occur on the upper bottom surface **252**. Moreover, plastic deformation of the third workpiece **33** reaches a maximum at the maximum diameter position MP of the flange **10***d*. However, since the upper bottom surface **252** is positioned at the side of the front end with respect to the maximum diameter position MP of the flange **10***d*, it is difficult for the deformation of the upper bottom surface **252**, which is caused by plastic deformation, to occur on the obtained fourth workpiece **34**. For these reasons, it is difficult for distortion or wrinkles or the like, which is generated by the distortion, to occur on the upper bottom surface **252** in the fourth workpiece **34**, so that it is difficult for cleaning liquid or the like used during plating to remain on the upper bottom surface **252**. Accordingly, plating is preferably performed on the fitting recess **25** in the pin terminal **10**. Further, it is difficult for rust or the like to occur on the upper bottom surface **252** in the pin terminal **10**.

Further, since knurling is performed on the upper end surface **520** of the protrusion **52***h* of the punch **52***g*, it is difficult for the protrusion **52***h* to slide in the second fitting recess **25***b* when pressure is applied to the third workpiece **33** by the punch **52***g*. Accordingly, it is possible to preferably form the third fitting recess **25***c*. For these reasons, the pin terminal **10** has high quality, and the quality of the glow plug eventually becomes high.

Furthermore, in the glow plug, the center shaft **7** has a tapered rear end portion having the diameter reduced toward the rear end and the rear end portion of the center shaft **7** is positioned inside the upper bottom surface **252**. For this reason, when the pin terminal **10** and the center shaft **7** are assembled, the rear end of the center shaft **7** is easily inserted into the fitting recess **25** since the rear end portion of the center shaft **7** has the above-mentioned tapered shape. Moreover, the rear end of the center shaft **7** inserted into the fitting recess **25** reaches the upper bottom surface **252** along the inner peripheral surface **251**. Accordingly, it is possible to preferably join the center shaft **7** to the pin terminal **10** with high joint strength so that the rear end portion of the center shaft **7** is positioned inside the upper bottom surface **252**. For this reason, the durability of the glow plug is improved.

In addition, since the upper bottom surface **252** is positioned in the pin terminal **10** at the position corresponding to the second cylindrical surface **23** as described above, the depth of the fitting recess **25** is relatively small. For this reason, it is possible to make the rear end of the center shaft **7** short. Accordingly, the whole center shaft **7** can be formed to be short in the glow plug, so that it is possible to reduce the manufacturing cost of the glow plug. Meanwhile, even though the depth of the fitting recess **25** is reduced and the rear end of the center shaft **7** becomes short as described above, the joint strength between the center shaft **7** and the pin terminal **10** is maintained high since the length β of the crimping portion **10***g* is a sufficient length as shown in FIG. **10**.

Further, the flange **10***d* includes the first cylindrical surface **21**, the convex curved surface **22**, and the second cylindrical surface **23**. Furthermore, the flange **10***d* includes the first disc surface **21***a*, the tapered surface **20** that is connected to the first disc surface **21***a* and the first cylindrical surface **21**, and the second disc surface **23***a* that is connected to the second cylindrical surface **23** and the large-diameter portion **10***b*. In addition, the step **22***c* is formed on the outer peripheral surface of the convex curved surface **22** of the flange **10***d* at the position slightly at the side of the front end with respect to the maximum diameter position MP.

For these reasons, the cap **97***a* is easily fitted to the pin terminal **10** and it is difficult for the cap **97***a*, which is locked to the engagement portion **10***e*, to be taken out from the pin terminal **10**. Specifically, since the cap **97***a* is mounted on the pin terminal **10** while the cap **97***a* is press-fitted in the direction of the arrow shown in FIG. **3**, the portion **971** to be locked of the cap main body **970** is elastically deformed so as to

expand along the first disc surface **21***a* and the tapered surface **20** and reaches the convex curved surface **22**. Further, the portion **971** to be locked is elastically deformed so as to further expand along the first arc **22***a* and reaches the maximum diameter position MP. While the portion **971** to be locked is elastically deformed so as to contract along the step **22***c* and the second arc **22***b* after passing the maximum diameter position MP, the portion **971** to be locked reaches the engagement portion **10***e*. Furthermore, the portion **971** to be locked is locked to the second cylindrical surface **23**. Since the mounting direction of the cap **97***a* on the pin terminal **10** is along the tapered surface **20** and the first arc **22***a* as described above, it is possible to easily fit the cap **97***a* to the pin terminal **10**.

Meanwhile, even though the portion **971** to be locked is deviated from the second cylindrical surface **23** due to the vibration and the like of a diesel engine and is moved in the direction where the cap **97***a* is taken out from the pin terminal **10**, that is, the direction opposite to the arrow shown in FIG. **3**, the portion **971** to be locked is caught by the step **22***c* and is locked to the step **22***c* as it is. Accordingly, for example, even though the engagement of the portion **971** to be locked caused by the second cylindrical surface **23** is released and the portion **971** to be locked is elastically deformed so as to expand along the second arc **22***b*, the portion **971** to be locked comes into contact with the step **22***c*. For this reason, the portion **971** to be locked does not expand larger than the second arc **22***b* and cannot reach the first arc **22***a* beyond the step **22***c*. As a result, the portion **971** to be locked is locked to the step **22***c*. Since the cap **97***a* is doubly locked by the second cylindrical surface **23** and the step **22***c* in the glow plug as described above, it is possible to more preferably fit the cap **97***a* to the pin terminal **10**.

In addition, in the fourth step, the step **22***c* is formed using a difference between the maximum diameter M of the first round hole **521** of the first cavity **52***c* and the maximum diameter N of the second round hole **522** of the second cavity **52***e*. For this reason, it is possible to suppress the generation of swarf of the fourth workpiece **34** as compared to, for example, the case where the step **22***c* is formed by cutting the entire outer peripheral surface of the convex curved surface **22**.

The embodiment of the invention has been described above. However, the invention is not limited to the above-mentioned embodiment, and it goes without saying that the invention may be appropriately modified without departing from the scope of the invention.

For example, a housing made of a resin may be employed in the glow plug instead of the main body bracket **3**.

Further, the heat generating tube **11**, the insulating powder **12**, and the heat generating coil **13** have been used as the heater **5** in the above-mentioned embodiment. However, a ceramic heater may be used as the heater.

Furthermore, as described above, the step **22**, the second cylindrical surface **23**, and the second disc surface **23***a* form the engagement portion **10***e*, and the portion **971** to be locked may be locked by these. In this case, it is more difficult for the portion **971**, which is to be locked, to be taken out from the engagement portion **10***e*, so that it is more difficult for the cap **97***a* to be taken out from the pin terminal **10***e*.

Moreover, the punches **50***c* and **51***c* may have the same structure as the structure of the punch **52***g* except for the lengths of the protrusions **50***d* and **51***d*. In this case, even when the first and second fitting recesses **25***a* and **25***b* are formed, it is difficult for the protrusions **50***d* and **51***d* to slide on the first and second workpieces **31** and **32** due to knurling that is performed on each of the upper end surfaces of the protrusions **50***d* and **51***d*. Accordingly, it is possible to preferably form the first and second fitting recesses **25***a* and **25***b*.

In addition, the step **22***c* may not be formed by the plastic working of the fourth step and may be formed by cutting when an outline finishing step is performed on the fourth workpiece **34**.

REFERENCE SIGNS LIST

87: conductive member
10*a*: small-diameter portion
10*d*: flange
25: fitting recess
10*b*: large-diameter portion
MP: maximum diameter position
10*e*: engagement portion
10: pin terminal
10*f*: crimp formation region
19: insulator (insulating member)
251: inner peripheral surface
252: upper bottom surface
3: main body bracket (housing)
5*a*: heat generating portion
5: heater
7: center shaft
17: O-ring
10*g*: crimping portion
251: inner peripheral surface
252: upper bottom surface
21: first cylindrical surface
22: convex curved surface
23: second cylindrical surface
22*c*: step
21*a*: first disc surface
20: tapered surface
23*a*: second disc surface

The invention claimed is:

1. A pin terminal for a glow plug comprising:

a small-diameter portion which has a shaft shape extending in an axial direction and is to be connected to a conductive member for supplying electric power from an outside;

a flange that is formed integrally with a front end of the small-diameter portion and is formed so as to have an outer diameter larger than an outer diameter of the small-diameter portion;

a cylindrical large-diameter portion that is formed integrally with a front end of the flange so as to be shorter than the small-diameter portion in the axial direction, is formed so as to have an outer diameter larger than the outer diameter of the small-diameter portion and smaller than the outer diameter of the flange, and includes a fitting recess formed therein in a radial direction so as to be recessed toward a rear end of the large-diameter portion from a front end of the large-diameter portion in the axial direction; and

an engagement portion which is positioned between a maximum diameter position of the flange and the large-diameter portion and has an outer diameter gradually reduced toward the large-diameter portion,

wherein the large-diameter portion includes a crimp formation region which is formed in a range from a front end of the large-diameter portion to a front end of the engagement portion so as to have an even outer diameter and be capable of being crimped,

wherein the flange includes a convex curved surface, said convex curved surface, when taken in cross-section in a direction perpendicular to the axial direction, having a circular shape, and

wherein a step is formed on the convex curved surface at a side of the cylindrical large-diameter portion with respect to the maximum diameter position, said step configured to inhibit an elastically deformable sleeve that is slidable over the pin terminal from sliding off.

2. The pin terminal according to claim **1**, wherein a diameter of a front end surface of the large-diameter portion, is dimensioned to engage a rear end surface of an insulating member.

3. The pin terminal according to claim **1**, wherein the fitting recess includes an inner peripheral surface that extends from the front end of the large-diameter portion toward the rear end of the large-diameter portion, and an upper bottom surface that continues to a rear end of the inner peripheral surface and is positioned inside the engagement portion or the flange in a radial direction of the engagement portion or the flange.

4. The pin terminal according to claim **3**, wherein the upper bottom surface has a tapered shape where a diameter of the upper bottom surface is reduced toward a rear end thereof.

5. The pin terminal according to claim **4**, wherein the upper bottom surface is positioned at a side of the front end of the flange with respect to the maximum diameter position of the flange.

6. The pin terminal according to claim **1**, wherein

the flange includes a first cylindrical surface that is positioned close to the small-diameter portion and has a diameter larger than the diameter of the small-diameter portion, the convex curved surface being connected to the first cylindrical surface and of which a cross-section in the axial direction forms an arc, and a second cylindrical surface that is connected to the convex curved surface and has the same diameter as the diameter of the first cylindrical surface.

7. The pin terminal according to claim **6**,

wherein the flange includes a first disc surface that is connected to the small-diameter portion, a tapered surface which is connected to the first disc surface and is tapered toward a rear end side thereof, and a second disc surface that connects the second disc surface to the large-diameter portion and extends in the direction perpendicular to the axial direction.

8. A glow plug comprising:

a cylindrical housing;

a heater that is fixed in the housing and includes a heat generating portion protruding from a front end of the housing;

a rod-like center shaft which is disposed in the housing and includes a rear end portion protruding from a rear end of the housing;

an insulating member which is provided at the rear end of the housing and into which the center shaft is inserted; and

a pin terminal that is fitted to the rear end portion of the center shaft and used for supplying electricity to the heat generating portion from an outside through the center shaft, wherein the pin terminal includes:

a small-diameter portion which has a shaft shape extending in an axial direction and is to be connected to a conductive member for supplying electric power from the outside;

a flange that is formed integrally with a front end of the small-diameter portion and is formed so as to have an outer diameter larger than an outer diameter of the small-diameter portion;

a cylindrical large-diameter portion that is formed integrally with a front end of the flange so as to be shorter than the small-diameter portion in the axial direction, is formed so as to have an outer diameter larger than the outer diameter of the small-diameter portion and smaller than the outer diameter of the flange, and includes a fitting recess formed therein in a radial direction so as to be recessed toward a rear end of the large-diameter portion from a front end of the large-diameter portion in the axial direction; and

an engagement portion which is positioned between a maximum diameter position of the flange and the large-diameter portion and has an outer diameter gradually reduced toward the large-diameter portion,

wherein the large-diameter portion includes a crimp formation region which is formed in a range from a front end of the large-diameter portion to a front end of the engagement portion so as to have an even outer diameter and be capable of being crimped,

wherein a part of the crimp formation region forms a crimping portion that fixes the rear end portion of the center shaft by crimping,

wherein the flange includes a convex curved surface, said convex curved surface, when taken in cross-section in a direction perpendicular to the axial direction, having a circular shape, and

wherein a step is formed on the convex curved surface at a side of the cylindrical large-diameter portion with respect to the maximum diameter position, said step configured to inhibit an elastically deformable sleeve that is slidable over the pin terminal from sliding off.

9. The glow plug according to claim **8**, wherein the crimping portion has a length that exceeds a half of an overall length of the crimp formation region in the axial direction.

10. The glow plug according to claim **9**, wherein the crimping portion is positioned at a side of a front end of the crimp formation region with respect to a middle of the crimp formation region in the axial direction.

11. The glow plug according to claim **8**, wherein the fitting recess includes an inner peripheral surface that extends from a front end of the large-diameter portion toward a rear end of the large-diameter portion, and an upper bottom surface that continues to a rear end of the inner peripheral surface and is positioned inside the engagement portion or the flange in a radial direction of the engagement portion or the flange,

the upper bottom surface has a tapered shape where a diameter of the upper bottom surface is reduced toward a rear end,

the center shaft has a tapered rear end portion having a diameter reduced toward a rear end, and

the rear end portion of the center shaft is positioned inside the upper bottom surface.

12. The glow plug according to claim **11**, wherein the upper bottom surface is positioned at the side of the front end with respect to the maximum diameter position of the flange.

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